FUNDAMENTAL PHYSICAL CONSTANTS

The 1986 CODATA Recommended Values

By E. Richard Cohen and Barry N. Taylor as published in the *Journal of Research of the National Bureau of Standards*, 92, 85, 1987. Discussions of the background, data selection and evaluation procedures are presented in CODATA Bulletin Number 63, November 1986, "The 1986 Adjustment of the Fundamental Physical Constants", a Report of the CODATA Task Group on Fundamental Physical Constants (36 pages) published by Pergamon Press.

The 1986 recommended values of the fundamental physical constants are given in five tables. Table 1 is an abbreviated list containing the quantities which should be of greatest interest to most users. Table 2 is a more complete compilation. Table 3 is a list of related "maintained units and standard values." Table 4 contains a number of scientifically, technologically, and metrologically useful energy conversion factors. Table 5 is an extended covariance matrix containing the variances, covariances, and correlation coefficients of the unknowns and a number of different constants (included for convenience) from which the like quantities of other constants may be calculated. (B. N. Taylor, W. H. Parker, and D. N. Langenberg, *Rev. Mod. Phys.*, 41, 375, 1969. Such a matrix is necessary because the variables in a least-square adjustment are correlated.

Table 1
SUMMARY OF THE 1986 RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS

Quantity	Symbol	Value	Units	Relative Uncertainty (ppm)
speed of light in vacuum	c	299 792 458	$\mathrm{m\,s^{-1}}$	(exact)
permeability of vacuum	μ_0	$4\pi \times 10^{-7}$	$\mathrm{N\,A^{-2}}$	
		=12.566 370 614...	$10^{-7}\,\mathrm{N\,A^{-2}}$	(exact)
permittivity of vacuum	ϵ_0	$1/\mu_0 c^2$		
		=8.854 187 817...	$10^{-12}\,\mathrm{F\,m^{-1}}$	(exact)
Newtonian constant of gravitation	G	6.672 59(85)	$10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$	128
Planck constant	h	6.626 0755(40)	$10^{-34}\,\mathrm{J\,s}$	0.60
$h/2\pi$	$\hbar$	1.054 572 66(63)	$10^{-34}\,\mathrm{J\,s}$	0.60
elementary charge	e	1.602 177 33(49)	$10^{-19}\,\mathrm{C}$	0.30
magnetic flux quantum, $h/2e$	Φ_0	2.067 834 61(61)	$10^{-15}\,\mathrm{Wb}$	0.30
electron mass	m_e	9.109 3897(54)	$10^{-31}\,\mathrm{kg}$	0.59
proton mass	m_p	1.672 6231(10)	$10^{-27}\,\mathrm{kg}$	0.59
proton-electron mass ratio	m_p/m_e	1836.152 701(37)		0.020
fine-structure constant, $\mu_0 ce^2/2h$	α	7.297 353 08(33)	10^{-3}	0.045
inverse fine-structure constant	α^{-1}	137.035 9895(61)		0.045
Rydberg constant, $m_e c\alpha^2/2h$	R_∞	10 973 731.534(13)	$\mathrm{m^{-1}}$	0.0012
Avogadro constant	N_A, L	6.022 1367(36)	$10^{23}\,\mathrm{mol^{-1}}$	0.59
Faraday constant, $N_A e$	F	96 485.309(29)	$\mathrm{C\,mol^{-1}}$	0.30
molar gas constant	R	8.314 510(70)	$\mathrm{J\,mol^{-1}\,K^{-1}}$	8.4
Boltzmann constant, R/N_A	k	1.380 658(12)	$10^{-23}\,\mathrm{J\,K^{-1}}$	8.5
Stefan–Boltzmann constant, $(\pi^2/60)k^4/\hbar^3c^2$	σ	5.670 51(19)	$10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$	34
		Non-SI units used with SI		
electron volt, $(e/\mathrm{C})\,\mathrm{J} = \{e\}\,\mathrm{J}$	eV	1.602 177 33(49)	$10^{-19}\,\mathrm{J}$	0.30
(unified) atomic mass unit, $1\,\mathrm{u} = m_u = \frac{1}{12}m(^{12}\mathrm{C})$	u	1.660 5402(10)	$10^{-27}\,\mathrm{kg}$	0.59

NOTE: An abbreviated list of the fundamental constants of physics and chemistry based on a least-squares adjustment with 17 degrees of freedom. The digits in parentheses are the one-standard-deviation uncertainty in the last digits of the given value. Since the uncertainties of many entries are correlated, the full covariance matrix must be used in evaluating the uncertainties of quantities computed from them.

Table 2
THE 1986 RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS

Quantity	Symbol	Value	Units	Relative Uncertainty (ppm)
		GENERAL CONSTANTS		
		Universal Constants		
speed of light in vacuum	c	299 792 458	$\mathrm{m\,s^{-1}}$	(exact)
permeability of vacuum	μ_0	$4\pi \times 10^{-7}$	$\mathrm{N\,A^{-2}}$	
		=12.566 370 614...	$10^{-7}\,\mathrm{N\,A^{-2}}$	(exact)
permittivity of vacuum	ϵ_0	$1/\mu_0 c^2$		
		=8.854 187 817...	$10^{-12}\,\mathrm{F\,m^{-1}}$	(exact)
Newtonian constant of gravitation	G	6.672 59(85)	$10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$	128
Planck constant	h	6.626 0755(40)	$10^{-34}\,\mathrm{J\,s}$	0.60
in electron volts, $h/\{e\}$		4.135 6692(12)	$10^{-15}\,\mathrm{eV\,s}$	0.30
$h/2\pi$	$\hbar$	1.054 572 66(63)	$10^{-34}\,\mathrm{J\,s}$	0.60
in electron volts, $\hbar/\{e\}$		6.582 1220(20)	$10^{-16}\,\mathrm{eV\,s}$	0.30

Table 2
THE 1986 RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS (continued)

Quantity	Symbol	Value	Units	Relative Uncertainty (ppm)
Planck mass, $(\hbar c/G)^{\frac{1}{2}}$	m_P	2.176 71(14)	10^{-8} kg	64
Planck length, $\hbar/m_P c = (\hbar G/c^3)^{\frac{1}{2}}$	l_P	1.616 05(10)	10^{-35} m	64
Planck time, $l_P/c = (\hbar G/c^5)^{\frac{1}{2}}$	t_P	5.390 56(34)	10^{-44} s	64
		Electromagnetic Constants		
elementary charge	e	1.602 177 33(49)	10^{-19} C	0.30
	e/h	2.417 988 36(72)	10^{14} A J^{-1}	0.30
magnetic flux quantum, $h/2e$	Φ_o	2.067 834 61(61)	10^{-15} Wb	0.30
Josephson frequency-voltage ratio	$2e/h$	4.835 9767(14)	10^{14} Hz V^{-1}	0.30
quantized Hall conductance	e^2/h	3.874 046 14(17)	10^{-5} S	0.045
quantized Hall resistance, $h/e^2 = \mu_o c/2\alpha$	R_H	25 812.8056(12)	Ω	0.045
Bohr magneton, $e\hbar/2m_e$	μ_B	9.274 0154(31)	10^{-24} J T^{-1}	0.34
in electron volts, $\mu_B/\{e\}$		5.788 382 63(52)	10^{-5} eV T^{-1}	0.089
in hertz, μ_B/h		1.399 624 18(42)	10^{10} Hz T^{-1}	0.30
in wavenumbers, μ_B/hc		46.686 437(14)	m^{-1} T^{-1}	0.30
in kelvins, μ_B/k		0.671 7099(57)	K T^{-1}	8.5
nuclear magneton, $e\hbar/2m_p$	μ_N	5.050 7866(17)	10^{-27} J T^{-1}	0.34
in electron volts, $\mu_N/\{e\}$		3.152 451 66(28)	10^{-8} eV T^{-1}	0.089
in hertz, μ_N/h		7.622 5914(23)	MHz T^{-1}	0.30
in wavenumbers, μ_N/hc		2.542 622 81(77)	10^{-2} m^{-1} T^{-1}	0.30
in kelvins, μ_N/k		3.658 246(31)	10^{-4} K T^{-1}	8.5
		ATOMIC CONSTANTS		
fine-structure constant, $\mu_o ce^2/2h$	α	7.297 353 08(33)	10^{-3}	0.045
inverse fine-structure constant	α^{-1}	137.035 9895(61)		0.045
Rydberg constant, $m_e c\alpha^2/2h$	R_∞	10 973 731.534(13)	m^{-1}	0.0012
in hertz, $R_\infty c$		3.289 841 9499(39)	10^{15} Hz	0.0012
in joules, $R_\infty hc$		2.179 8741(13)	10^{-18} J	0.60
in eV, $R_\infty hc/\{e\}$		13.605 6981(40)	eV	0.30
Bohr radius, $\alpha/4\pi R_\infty$	a_o	0.529 177 249(24)	10^{-10} m	0.045
Hartree energy, $e^2/4\pi\epsilon_o a_o = 2R_\infty hc$	E_h	4.359 7482(26)	10^{-18} J	0.60
in eV, $E_h/\{e\}$		27.211 3961(81)	eV	0.30
quantum of circulation	$h/2m_e$	3.636 948 07(33)	10^{-4} m^2 s^{-1}	0.089
	h/m_e	7.273 896 14(65)	10^{-4} m^2 s^{-1}	0.089
		Electron		
electron mass	m_e	9.109 3897(54)	10^{-31} kg	0.59
		5.485 799 03(13)	10^{-4} u	0.023
in electron volts, $m_e c^2/\{e\}$		0.510 999 06(15)	MeV	0.30
electron–muon mass ratio	m_e/m_μ	4.836 332 18(71)	10^{-3}	0.15
electron–proton mass ratio	m_e/m_p	5.446 170 13(11)	10^{-4}	0.020
electron–deuteron mass ratio	m_e/m_d	2.724 437 07(6)	10^{-4}	0.020
electron–α-particle mass ratio	m_e/m_α	1.370 933 54(3)	10^{-4}	0.021
electron specific charge	$-e/m_e$	−1.758 819 62(53)	10^{11} C kg^{-1}	0.30
electron molar mass	$M(e), M_e$	5.485 799 03(13)	10^{-7} kg/mol	0.023
Compton wavelength, $h/m_e c$	λ_C	2.426 310 58(22)	10^{-12} m	0.089
$\lambda_C/2\pi = \alpha a_o = \alpha^2/4\pi R_\infty$	λ_C	3.861 593 23(35)	10^{-13} m	0.089
classical electron radius, $\alpha^2 a_o$	r_e	2.817 940 92(38)	10^{-15} m	0.13
Thomson cross section, $(8\pi/3)r_e^2$	σ_e	0.665 246 16(18)	10^{-28} m^2	0.27
electron magnetic moment	μ_e	928.477 01(31)	10^{-26} J T^{-1}	0.34
in Bohr magnetons	μ_e/μ_B	1.001 159 652 193(10)		1×10^{-5}
in nuclear magnetons	μ_e/μ_N	1838.282 000(37)		0.020
electron magnetic moment anomaly, $\mu_e/\mu_B - 1$	a_e	1.159 652 193(10)	10^{-3}	0.0086
electron g-factor, $2(1 + a_e)$	g_e	2.002 319 304 386(20)		1×10^{-5}
electron–muon magnetic moment ratio	μ_e/μ_μ	206.766 967(30)		0.15
electron–proton magnetic moment ratio	μ_e/μ_p	658.210 6881(66)		0.010
		Muon		
muon mass	m_μ	1.883 5327(11)	10^{-28} kg	0.61
		0.113 428 913(17)	u	0.15
in electron volts, $m_\mu c^2/\{e\}$		105.658 389(34)	MeV	0.32
muon–electron mass ratio	m_μ/m_e	206.768 262(30)		0.15
muon molar mass	$M(\mu), M_\mu$	1.134 289 13(17)	10^{-4} kg/mol	0.15
muon magnetic moment	μ_μ	4.490 4514(15)	10^{-26} J T^{-1}	0.33
in Bohr magnetons,	μ_μ/μ_B	4.841 970 97(71)	10^{-3}	0.15
in nuclear magnetons,	μ_μ/μ_N	8.890 5981(13)		0.15

Table 2
THE 1986 RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS (continued)

Quantity	Symbol	Value	Units	Relative Uncertainty (ppm)
muon magnetic moment anomaly, $[\mu_\mu/(e\hbar/2m_\mu)] - 1$	a_μ	1.1659230(84)	10^{-3}	7.2
muon g-factor, $2(1+a_\mu)$	g_μ	2.002331846(17)		0.0084
muon–proton magnetic moment ratio	μ_μ/μ_p	3.18334547(47)		0.15
Proton				
proton mass	m_p	1.6726231(10)	10^{-27} kg	0.59
		1.007276470(12)	u	0.012
in electron volts, $m_pc^2/\{e\}$		938.27231(28)	MeV	0.30
proton–electron mass ratio	m_p/m_e	1836.152701(37)		0.020
proton–muon mass ratio	m_p/m_μ	8.8802444(13)		0.15
proton specific charge	e/m_p	9.5788309(29)	10^7 C kg^{-1}	0.30
proton molar mass	$M(p), M_p$	1.007276470(12)	10^{-3} kg/mol	0.012
proton Compton wavelength, h/m_pc	$\lambda_{C,p}$	1.32141002(12)	10^{-15} m	0.089
$\lambda_{C,p}/2\pi$	$\lambda_{C,p}$	2.10308937(19)	10^{-16} m	0.089
proton magnetic moment	μ_p	1.41060761(47)	10^{-26} J T^{-1}	0.34
in Bohr magnetons	μ_p/μ_B	1.521032202(15)	10^{-3}	0.010
in nuclear magnetons	μ_p/μ_N	2.792847386(63)		0.023
diamagnetic shielding correction for protons in pure water, spherical sample, 25 °C, $1-\mu_p'/\mu_p$	σ_{H_2O}	25.689(15)	10^{-6}	–
shielded proton moment (H_2O, sph., 25 °C)	μ_p'	1.41057138(47)	10^{-26} J T^{-1}	0.34
in Bohr magnetons	μ_p'/μ_B	1.520993129(17)	10^{-3}	0.011
in nuclear magnetons	μ_p'/μ_N	2.792775642(64)		0.023
proton gyromagnetic ratio	γ_p	26752.2128(81)	10^4 s^{-1} T^{-1}	0.30
	$\gamma_p/2\pi$	42.577469(13)	MHz T^{-1}	0.30
uncorrected (H_2O, sph., 25 °C)	γ_p'	26751.5255(81)	10^4 s^{-1} T^{-1}	0.30
	$\gamma_p'/2\pi$	42.576375(13)	MHz T^{-1}	0.30
Neutron				
neutron mass	m_n	1.6749286(10)	10^{-27} kg	0.59
		1.008664904(14)	u	0.014
in electron volts, $m_nc^2/\{e\}$		939.56563(28)	Mev	0.30
neutron–electron mass ratio	m_n/m_e	1838.683662(40)		0.022
neutron–proton mass ratio	m_n/m_p	1.001378404(9)		0.009
neutron molar mass	$M(n), M_n$	1.008664904(14)	10^{-3} kg/mol	0.014
neutron Compton wavelength, h/m_nc	$\lambda_{C,n}$	1.31959110(12)	10^{-15} m	0.089
$\lambda_{C,n}/2\pi$	$\lambda_{C,n}$	2.10019445(19)	10^{-16} m	0.089
neutron magnetic moment *	μ_n	0.96623707(40)	10^{-26} J T^{-1}	0.41
in Bohr magnetons	μ_n/μ_B	1.04187563(25)	10^{-3}	0.24
in nuclear magnetons	μ_n/μ_N	1.91304275(45)		0.24
neutron–electron magnetic moment ratio	μ_n/μ_e	1.04066882(25)	10^{-3}	0.24
neutron–proton magnetic moment ratio	μ_n/μ_p	0.68497934(16)		0.24
Deuteron				
deuteron mass	m_d	3.3435860(20)	10^{-27} kg	0.59
		2.013553214(24)	u	0.012
in electron volts, $m_dc^2/\{e\}$		1875.61339(57)	MeV	0.30
deuteron–electron mass ratio	m_d/m_e	3670.483014(75)		0.020
deuteron–proton mass ratio	m_d/m_p	1.999007496(6)		0.003
deuteron molar mass	$M(d), M_d$	2.013553214(24)	10^{-3} kg/mol	0.012
deuteron magnetic moment *	μ_d	0.43307375(15)	10^{-26} J T^{-1}	0.34
in Bohr magnetons,	μ_d/μ_B	0.4669754479(91)	10^{-3}	0.019
in nuclear magnetons,	μ_d/μ_N	0.857438230(24)		0.028
deuteron–electron magnetic moment ratio	μ_d/μ_e	0.4664345460(91)	10^{-3}	0.019
deuteron–proton magnetic moment ratio	μ_d/μ_p	0.3070122035(51)		0.017
PHYSICO-CHEMICAL CONSTANTS				
Avogadro constant	N_A, L	6.0221367(36)	10^{23} mol^{-1}	0.59
atomic mass constant, $\frac{1}{12}m(^{12}C)$	m_u	1.6605402(10)	10^{-27} kg	0.59
in electron volts, $m_uc^2/\{e\}$		931.49432(28)	MeV	0.30
Faraday constant	F	96485.309(29)	C mol^{-1}	0.30
molar Planck constant	N_Ah	3.99031323(36)	10^{-10} J s mol^{-1}	0.089
	N_Ahc	0.11962658(11)	J m mol^{-1}	0.089
molar gas constant	R	8.314510(70)	J mol^{-1} K^{-1}	8.4

Table 2
THE 1986 RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS (continued)

Quantity	Symbol	Value	Units	Relative Uncertainty (ppm)
Boltzmann constant, R/N_A	k	1.380 658(12)	10^{-23} J K^{-1}	8.5
in electron volts, $k/\{e\}$		8.617 385(73)	10^{-5} eV K^{-1}	8.4
in hertz, k/h		2.083 674(18)	10^{10} Hz K^{-1}	8.4
in wavenumbers, k/hc		69.503 87(59)	m^{-1} K^{-1}	8.4
molar volume (ideal gas), RT/p				
$T = 273.15$ K, $p = 101\,325$ Pa	V_m	22.414 10(19)	L/mol	8.4
Loschmidt constant, N_A/V_m	n_o	2.686 763(23)	10^{25} m^{-3}	8.5
$T = 273.15$ K, $p = 100$ kPa	V_m	22.711 08(19)	L/mol	8.4
Sackur-Tetrode constant (absolute entropy constant), **				
$\frac{5}{2} + \ln\{(2\pi m_u kT_1/h^2)^{\frac{3}{2}} kT_1/p_o\}$				
$T_1 = 1$ K, $p_o = 100$ kPa	S_o/R	−1.151 693(21)		18
$p_o = 101\,325$ Pa		−1.164 856(21)		18
Stefan–Boltzmann constant, $(\pi^2/60)k^4/\hbar^3c^2$	σ	5.670 51(19)	10^{-8} W m^{-2} K^{-4}	34
first radiation constant, $2\pi hc^2$	c_1	3.741 7749(22)	10^{-16} W m^2	0.60
second radiation constant, hc/k	c_2	0.014 387 69(12)	m K	8.4
Wien displacement law constant, $b = \lambda_{max}T = c_2/4.965\,114\,23\ldots$	b	2.897 756(24)	10^{-3} m K	8.4

NOTE: This list of the fundamental constants of physics and chemistry is based on a least-squares adjustment with 17 degrees of freedom. The digits in parentheses are the one-standard-deviation uncertainty in the last digits of the given value. Since the uncertainties of many of these entries are correlated, the full covariance matrix must be used in evaluating the uncertainties of quantities computed from them.

* The scalar magnitude of the neutron moment is listed here. The neutron magnetic dipole is directed oppositely to that of the proton, and corresponds to the dipole associated with a spinning negative charge distribution. The vector sum, $\mu_d = \mu_p + \mu_n$, is approximately satisfied.

** The entropy of an ideal monatomic gas of relative atomic weight A_r is given by $S = S_o + \frac{1}{2}R \ln A_r - R \ln (p/p_o) + \frac{5}{2}R \ln(T/K)$.

Table 3
MAINTAINED UNITS AND STANDARD VALUES

Quantity	Symbol	Value	Units	Relative Uncertainty (ppm)
electron volt, (e/C) J = $\{e\}$ J	eV	1.602 177 33(49)	10^{-19} J	0.30
(unified) atomic mass unit, $1\ u = m_u = \frac{1}{12}m(^{12}C)$	u	1.660 5402(10)	10^{-27} kg	0.59
standard atmosphere	atm	101 325	Pa	(exact)
standard acceleration of gravity	g_n	9.806 65	m s^{-2}	(exact)
		'As-Maintained' Electrical Units		
BIPM maintained ohm, Ω_{69-BI}				
$\Omega_{BI85} \equiv \Omega_{69-BI}$(1 Jan 1985)	Ω_{BI85}	$1 - 1.563(50) \times 10^{-6}$	Ω	
		$= 0.999\,998\,437(50)$	Ω	0.050
Drift rate of Ω_{69-BI}	$\frac{d\Omega_{69-BI}}{dt}$	−0.0566(15)	$\mu\Omega$/a	—
BIPM maintained volt,	V_{76-BI}	$1 - 7.59(30) \times 10^{-6}$	V	
$V_{76-BI} \equiv 483\,594$ GHz$(h/2e)$		$= 0.999\,992\,41(30)$	V	0.30
BIPM maintained ampere,	A_{BI85}	$1 - 6.03(30) \times 10^{-6}$	A	
$A_{BIPM} = V_{76-BI}/\Omega_{69-BI}$		$= 0.999\,993\,97(30)$	A	0.30
		X-Ray Standards		
Cu x-unit : $\lambda(CuK\alpha_1) \equiv 1537.400$ xu	xu(CuKα_1)	1.002 077 89(70)	10^{-13} m	0.70
Mo x-unit : $\lambda(MoK\alpha_1) \equiv 707.831$ xu	xu(MoKα_1)	1.002 099 38(45)	10^{-13} m	0.45
Å* : $\lambda(WK\alpha_1) \equiv 0.209\,100$ Å*	Å*	1.000 014 81(92)	10^{-10} m	0.92

Table 3
MAINTAINED UNITS AND STANDARD VALUES
(continued)

Quantity	Symbol	Value	Units	Relative Uncertainty (ppm)
lattice spacing of Si (in vacuum, 22.5 °C), +	a	0.543 101 96(11)	nm	0.21
$d_{220} = a/\sqrt{8}$	d_{220}	0.192 015 540(40)	nm	0.21
molar volume of Si, $M(\mathrm{Si})/\rho(\mathrm{Si}) = N_A a^3/8$	$V_m(\mathrm{Si})$	12.058 8179(89)	$\mathrm{cm^3/mol}$	0.74

NOTE: A summary of "maintained" units and "standard" values and their relationship to SI units, based on a least-squares adjustment with 17 degrees of freedom. The digits in parentheses are the one-standard-deviation uncertainty in the last digits of the given value. Since the uncertainties of many of these entries are correlated, the full covariance matrix must be used in evaluating the uncertainties of quantities computed from them.

+ The lattice spacing of single-crystal Si can vary by parts in 10^7 depending on the preparation process. Measurements at PTB indicate also the possibility of distortions from exact cubic symmetry of the order of 0.2 ppm.

Table 4
ENERGY CONVERSION FACTORS

	J	kg	$\mathrm{m^{-1}}$	Hz
1 J =	1	$1/\{c^2\}$ $1.112\,650\,06 \times 10^{-17}$	$1/\{hc\}$ $5.034\,1125(30) \times 10^{24}$	$1/\{h\}$ $1.509\,183\,97(90) \times 10^{33}$
1 kg =	$\{c^2\}$ $8.987\,551\,787 \times 10^{16}$	1	$\{c/h\}$ $4.524\,4347(27) \times 10^{41}$	$\{c^2/h\}$ $1.356\,391\,40(81) \times 10^{50}$
1 $\mathrm{m^{-1}}$ =	$\{hc\}$ $1.986\,4475(12) \times 10^{-25}$	$\{h/c\}$ $2.210\,2209(13) \times 10^{-42}$	1	$\{c\}$ 299 792 458
1 Hz =	$\{h\}$ $6.626\,0755(40) \times 10^{-34}$	$\{h/c^2\}$ $7.372\,5032(44) \times 10^{-51}$	$1/\{c\}$ $3.335\,640\,952 \times 10^{-9}$	1
1 K =	$\{k\}$ $1.380\,658(12) \times 10^{-23}$	$\{k/c^2\}$ $1.536\,189(13) \times 10^{-40}$	$\{k/hc\}$ 69.503 87(59)	$\{k/h\}$ $2.083\,674(18) \times 10^{10}$
1 eV =	$\{e\}$ $1.602\,177\,33(49) \times 10^{-19}$	$\{e/c^2\}$ $1.782\,662\,70(54) \times 10^{-36}$	$\{e/hc\}$ 806 554.10(24)	$\{e/h\}$ $2.417\,988\,36(72) \times 10^{14}$
1 u =	$\{m_u c^2\}$ $1.492\,419\,09(88) \times 10^{-10}$	$\{m_u\}$ $1.660\,5402(10) \times 10^{-27}$	$\{m_u c/h\}$ $7.513\,005\,63(67) \times 10^{14}$	$\{m_u c^2/h\}$ $2.252\,342\,42(20) \times 10^{23}$
1 hartree =	$\{2R_\infty hc\}$ $4.359\,7482(26) \times 10^{-18}$	$\{2R_\infty h/c\}$ $4.850\,3741(29) \times 10^{-35}$	$\{2R_\infty\}$ 21 947 463.067(26)	$\{2R_\infty c\}$ $6.579\,683\,8999(78) \times 10^{15}$

	K	eV	u	hartree
1 J =	$1/\{k\}$ $7.242\,924(61) \times 10^{22}$	$1/\{e\}$ $6.241\,5064(19) \times 10^{18}$	$1/\{m_u c^2\}$ $6.700\,5308(40) \times 10^{9}$	$1/\{2R_\infty hc\}$ $2.293\,7104(14) \times 10^{17}$
1 kg =	$\{c^2/k\}$ $6.509\,616(55) \times 10^{39}$	$\{c^2/e\}$ $5.609\,5862(17) \times 10^{35}$	$1/\{m_u\}$ $6.022\,1367(36) \times 10^{26}$	$\{c/2R_\infty h\}$ $2.061\,4841(12) \times 10^{34}$
1 $\mathrm{m^{-1}}$ =	$\{hc/k\}$ 0.014 387 69(12)	$\{hc/e\}$ $1.239\,842\,44(37) \times 10^{-6}$	$\{h/m_u c\}$ $1.331\,025\,22(12) \times 10^{-15}$	$1/\{2R_\infty\}$ $4.556\,335\,2672(54) \times 10^{-8}$
1 Hz =	$\{h/k\}$ $4.799\,216(41) \times 10^{-11}$	$\{h/e\}$ $4.135\,6692(12) \times 10^{-15}$	$\{h/m_u c^2\}$ $4.439\,822\,24(40) \times 10^{-24}$	$1/\{2R_\infty c\}$ $1.519\,829\,8508(18) \times 10^{-16}$
1 K =	1	$\{k/e\}$ $8.617\,385(73) \times 10^{-5}$	$\{k/m_u c^2\}$ $9.251\,140(78) \times 10^{-14}$	$\{k/2R_\infty hc\}$ $3.166\,829(27) \times 10^{-6}$
1 eV =	$\{e/k\}$ 11 604.45(10)	1	$\{e/m_u c^2\}$ $1.073\,543\,85(33) \times 10^{-9}$	$\{e/2R_\infty hc\}$ 0.036 749 309(11)
1 u =	$\{m_u c^2/k\}$ $1.080\,9478(91) \times 10^{13}$	$\{m_u c^2/e\}$ $931.494\,32(28) \times 10^{6}$	1	$\{m_u c/2R_\infty h\}$ $3.423\,177\,25(31) \times 10^{7}$
1 hartree =	$\{2R_\infty hc/k\}$ $3.157\,733(27) \times 10^{5}$	$\{2R_\infty hc/e\}$ 27.211 3961(81)	$\{2R_\infty h/m_u c\}$ $2.921\,262\,69(26) \times 10^{-8}$	1

NOTE: To use this table note that all entries on the same line are equal; the unit at the top of a column applies to all of the values beneath it. Example: 1 eV = 806544.10 $\mathrm{m^{-1}}$.

Table 5
EXPANDED COVARIANCE AND CORRELATION COEFFICIENT MATRIX FOR THE 1986 RECOMMENDED SET OF FUNDAMENTAL PHYSICAL CONSTANTS

	α^{-1}	K_V	K_Ω	μ_μ/μ_p	e	h	m_e	N_A	F
α^{-1}	1997	−1062	925	3267	−3059	−4121	−127	127	−2932
K_V	*−0.080*	87988	90	−1737	89050	177038	174914	−174914	−85864
K_Ω	*0.416*	*0.006*	2477	1513	−835	−744	1105	−1105	−1939
μ_μ/μ_p	*0.498*	*−0.040*	*0.207*	21523	−5004	−6742	−206	208	−4796
e	*−0.226*	*0.989*	*−0.055*	*−0.112*	92109	181159	175042	−175042	−82933
h	*−0.154*	*0.997*	*−0.025*	*−0.077*	*0.997*	358197	349956	−349956	−168797
m_e	*−0.005*	*0.997*	*0.038*	*−0.002*	*0.975*	*0.989*	349702	−349702	−174660
N_A	*0.005*	*−0.997*	*−0.033*	*0.002*	*−0.975*	*−0.989*	*−1.000*	349702	174660
F	*−0.217*	*−0.956*	*−0.129*	*−0.108*	*−0.902*	*−0.931*	*−0.975*	*0.975*	91727

The elements of the covariance matrix appear on and above the major diagonal in (parts in $10^9)^2$; correlation coefficients appear in *italics* below the diagonal. The values are given to as many as six digits only as a matter of consistency. The correlation coefficient between m_e and N_A appears as -1.000 in this table because the auxiliary constants were considered to be exact in carrying out the least-squares adjustment. When the uncertainties of m_p/m_e and M_p are properly taken into account, the correlation coefficient is -0.999 and the variances of m_e and N_A are slightly increased.

STANDARD ATOMIC WEIGHTS (1989)
(Scaled to A_r (^{12}C) = 12)

The atomic weights of many elements are not invariant but depend on the origin and treatment of the material. The footnotes to this table elaborate the types of variation to be expected for individual elements. The values of A_r(E) and uncertainty U_r(E) given here apply to elements as they exist naturally on earth. New values recommended by IUPAC in 1989 are included.

Name	Symbol	Atomic no.	Atomic weight	Footnotes			
Actinium*	Ac	89					A
Aluminium	Al	13	26.981539(5)				
Americium*	Am	95					A
Antimony	Sb	51	121.757(3)				
Argon	Ar	18	39.948(1)	g		r	
Arsenic	As	33	74.92159(2)				
Astatine*	At	85					A
Barium	Ba	56	137.327(7)				
Berkelium*	Bk	97					A
Beryllium	Be	4	9.012182(3)				
Bismuth	Bi	83	208.98037(3)				
Boron	B	5	10.811(5)	g	m	r	
Bromine	Br	35	79.904(1)				
Cadmium	Cd	48	112.411(8)	g			
Caesium	Cs	55	132.90543(5)				
Calcium	Ca	20	40.078(4)	g			
Californium*	Cf	98					A
Carbon	C	6	12.011(1)			r	
Cerium	Ce	58	140.115(4)	g			
Chlorine	Cl	17	35.4527(9)				
Chromium	Cr	24	51.9961(6)				
Cobalt	Co	27	58.93320(1)				
Copper	Cu	29	63.546(3)			r	
Curium*	Cm	96					A
Dysprosium	Dy	66	162.50(3)	g			
Einsteinium*	Es	99					A
Erbium	Er	68	167.26(3)	g			
Europium	Eu	63	151.965(9)	g			
Fermium*	Fm	100					A
Fluorine	F	9	18.9984032(9)				
Francium*	Fr	87					A
Gadolinium	Gd	64	157.25(3)	g			
Gallium	Ga	31	69.723(1)				
Germanium	Ge	32	72.61(2)				
Gold	Au	79	196.96654(3)				
Hafnium	Hf	72	178.49(2)				
Helium	He	2	4.002602(2)	g		r	
Holmium	Ho	67	164.93032(3)				
Hydrogen	H	1	1.00794(7)	g	m	r	
Indium	In	49	114.82(1)				
Iodine	I	53	126.90447(3)				
Iridium	Ir	77	192.22(3)				
Iron	Fe	26	55.847(3)				
Krypton	Kr	36	83.80(1)	g	m		
Lanthanum	La	57	138.9055(2)	g			
Lawrencium*	Lr	103					A
Lead	Pb	82	207.2(1)	g		r	
Lithium	Li	3	6.941(2)	g	m	r	
Lutetium	Lu	71	174.967(1)	g			
Magnesium	Mg	12	24.3050(6)				
Manganese	Mn	25	54.93805(1)				
Mendelevium*	Md	101					A
Mercury	Hg	80	200.59(2)				
Molybdenum	Mo	42	95.94(1)				
Neodymium	Nd	60	144.24(3)	g			
Neon	Ne	10	20.1797(6)	g	m		
Neptunium*	Np	93					A
Nickel	Ni	28	58.6934(2)				
Niobium	Nb	41	92.90638(2)				
Nitrogen	N	7	14.00674(7)	g		r	
Nobelium*	No	102					A
Osmium	Os	76	190.2(1)	g			
Oxygen	O	8	15.9994(3)	g		r	
Palladium	Pd	46	106.42(1)	g			

STANDARD ATOMIC WEIGHTS (1989)
(Scaled to A_r (^{12}C) = 12) (continued)

Name	Symbol	Atomic no.	Atomic weight	Footnotes
Phosphorus	P	15	30.973762(4)	
Platinum	Pt	78	195.08(3)	
Plutonium*	Pu	94		A
Polonium*	Po	84		A
Potassium	K	19	39.0983(1)	
Praseodymium	Pr	59	140.90765(3)	
Promethium*	Pm	61		A
Protactinium*	Pa	91	231.03588(2)	Z
Radium*	Ra	88		A
Radon*	Rn	86		A
Rhenium	Re	75	186.207(1)	
Rhodium	Rh	45	102.90550(3)	
Rubidium	Rb	37	85.4678(3)	g
Ruthenium	Ru	44	101.07(2)	g
Samarium	Sm	62	150.36(3)	g
Scandium	Sc	21	44.955910(9)	
Selenium	Se	34	78.96(3)	
Silicon	Si	14	28.0855(3)	r
Silver	Ag	47	107.8682(2)	g
Sodium	Na	11	22.989768(6)	
Strontium	Sr	38	87.62(1)	g r
Sulfur	S	16	32.066(6)	r
Tantalum	Ta	73	180.9479(1)	
Technetium*	Tc	43		A
Tellurium	Te	52	127.60(3)	g
Terbium	Tb	65	158.92534(3)	
Thallium	Tl	81	204.3833(2)	
Thorium*	Th	90	232.0381(1)	g Z
Thulium	Tm	69	168.93421(3)	
Tin	Sn	50	118.710(7)	g
Titanium	Ti	22	47.88(3)	
Tungsten	W	74	183.85(3)	
Unnilquadium	Unq	104		A
Unnilpentium	Unp	105		A
Unnilhexium	Unh	106		A
Unnilseptium	Uns	107		A
Uranium*	U	92	238.0289(1)	g m Z
Vanadium	V	23	50.9415(1)	
Xenon	Xe	54	131.29(2)	g m
Ytterbium	Yb	70	173.04(3)	g
Yttrium	Y	39	88.90585(2)	
Zinc	Zn	30	65.39(2)	
Zirconium	Zr	40	91.224(2)	g

g geological specimens are known in which the element has an isotopic composition outside the limits for normal material. The difference between the atomic weight of the element in such specimens and that given in the table may exceed the implied uncertainty.

m modified isotopic compositions may be found in commercially available material because it has been subjected to an undisclosed or inadvertent isotopic separation. Substantial deviations in atomic weight of the element from that given in the table can occur.

r range in isotopic composition of normal terrestrial material prevents a more precise $A_r(E)$ being given; the tabulated $A_r(E)$ value should be applicable to any normal material.

A Radioactive element that lacks a characteristic terrestrial isotopic composition.

Z An element, without stable nuclide(s), exhibiting a range of characteristic terrestrial compositions of long-lived radionuclide(s) such that a meaningful atomic weight can be given.

* Element has no stable nuclides.

ELECTRON CONFIGURATION OF NEUTRAL ATOMS IN THE GROUND STATE (continued)

		K	L		M			N				O				P			Q
Atomic	n =	1	2		3			4				5				6			7
no.	Element	s	s	p	s	p	d	s	p	d	f	s	p	d	f	s	p	d	s
57	La	2	2	6	2	6	10	2	6	10		2	6	1		2			
58	Ce	2	2	6	2	6	10	2	6	10	1*	2	6	1		2			
59	Pr	2	2	6	2	6	10	2	6	10	3	2	6			2			
60	Nd	2	2	6	2	6	10	2	6	10	4	2	6			2			
61	Pm	2	2	6	2	6	10	2	6	10	5	2	6			2			
62	Sm	2	2	6	2	6	10	2	6	10	6	2	6			2			
63	Eu	2	2	6	2	6	10	2	6	10	7	2	6			2			
64	Gd	2	2	6	2	6	10	2	6	10	7	2	6	1		2			
65	Tb	2	2	6	2	6	10	2	6	10	9*	2	6			2			
66	Dy	2	2	6	2	6	10	2	6	10	10	2	6			2			
67	Ho	2	2	6	2	6	10	2	6	10	11	2	6			2			
68	Er	2	2	6	2	6	10	2	6	10	12	2	6			2			
69	Tm	2	2	6	2	6	10	2	6	10	13	2	6			2			
70	Yb	2	2	6	2	6	10	2	6	10	14	2	6			2			
71	Lu	2	2	6	2	6	10	2	6	10	14	2	6	1		2			
72	Hf	2	2	6	2	6	10	2	6	10	14	2	6	2		2			
73	Ta	2	2	6	2	6	10	2	6	10	14	2	6	3		2			
74	W	2	2	6	2	6	10	2	6	10	14	2	6	4		2			
75	Re	2	2	6	2	6	10	2	6	10	14	2	6	5		2			
76	Os	2	2	6	2	6	10	2	6	10	14	2	6	6		2			
77	Ir	2	2	6	2	6	10	2	6	10	14	2	6	7		2			
78	Pt	2	2	6	2	6	10	2	6	10	14	2	6	9		1			
79	Au	2	2	6	2	6	10	2	6	10	14	2	6	10		1			
80	Hg	2	2	6	2	6	10	2	6	10	14	2	6	10		2			
81	Tl	2	2	6	2	6	10	2	6	10	14	2	6	10		2	1		
82	Pb	2	2	6	2	6	10	2	6	10	14	2	6	10		2	2		
83	Bi	2	2	6	2	6	10	2	6	10	14	2	6	10		2	3		
84	Po	2	2	6	2	6	10	2	6	10	14	2	6	10		2	4		
85	At	2	2	6	2	6	10	2	6	10	14	2	6	10		2	5		
86	Rn	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6		
87	Fr	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6		1
88	Ra	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6		2
89	Ac	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	1	2
90	Th	2	2	6	2	6	10	2	6	10	14	2	6	10		2	6	2	2
91	Pa	2	2	6	2	6	10	2	6	10	14	2	6	10	2*	2	6	1	2
92	U	2	2	6	2	6	10	2	6	10	14	2	6	10	3	2	6	1	2
93	Np	2	2	6	2	6	10	2	6	10	14	2	6	10	4	2	6	1	2
94	Pu	2	2	6	2	6	10	2	6	10	14	2	6	10	6*	2	6		2
95	Am	2	2	6	2	6	10	2	6	10	14	2	6	10	7	2	6		2
96	Cm	2	2	6	2	6	10	2	6	10	14	2	6	10	7*	2	6	1	2
97	Bk	2	2	6	2	6	10	2	6	10	14	2	6	10	9	2	6		2
98	Cf	2	2	6	2	6	10	2	6	10	14	2	6	10	10	2	6		2
99	Es	2	2	6	2	6	10	2	6	10	14	2	6	10	11	2	6		2
100	Fm	2	2	6	2	6	10	2	6	10	14	2	6	10	12	2	6		2
101	Md	2	2	6	2	6	10	2	6	10	14	2	6	10	13	2	6		2
102	No	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6		2
103	Lr	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	1	2
104	Rf	2	2	6	2	6	10	2	6	10	14	2	6	10	14	2	6	2	2

* Note irregularity.

REFERENCE

W. L. Wiese and G. A. Martin, in *A Physicist's Desk Reference*, American Institute of Physics, New York, 1989, 94.

ELECTRON CONFIGURATION OF NEUTRAL ATOMS IN THE GROUND STATE

Atomic no.	n = Element	K 1 s	L 2 s	p	M 3 s	p	d	N 4 s	p	d	f	O 5 s	p	d	f	P 6 s	p	d	Q 7 s
1	H	1																	
2	He	2																	
3	Li	2	1																
4	Be	2	2																
5	B	2	2	1															
6	C	2	2	2															
7	N	2	2	3															
8	O	2	2	4															
9	F	2	2	5															
10	Ne	2	2	6															
11	Na	2	2	6	1														
12	Mg	2	2	6	2														
13	Al	2	2	6	2	1													
14	Si	2	2	6	2	2													
15	P	2	2	6	2	3													
16	S	2	2	6	2	4													
17	Cl	2	2	6	2	5													
18	Ar	2	2	6	2	6													
19	K	2	2	6	2	6		1											
20	Ca	2	2	6	2	6		2											
21	Sc	2	2	6	2	6	1	2											
22	Ti	2	2	6	2	6	2	2											
23	V	2	2	6	2	6	3	2											
24	Cr	2	2	6	2	6	5*	1											
25	Mn	2	2	6	2	6	5	2											
26	Fe	2	2	6	2	6	6	2											
27	Co	2	2	6	2	6	7	2											
28	Ni	2	2	6	2	6	8	2											
29	Cu	2	2	6	2	6	10*	1											
30	Zn	2	2	6	2	6	10	2											
31	Ga	2	2	6	2	6	10	2	1										
32	Ge	2	2	6	2	6	10	2	2										
33	As	2	2	6	2	6	10	2	3										
34	Se	2	2	6	2	6	10	2	4										
35	Br	2	2	6	2	6	10	2	5										
36	Kr	2	2	6	2	6	10	2	6										
37	Rb	2	2	6	2	6	10	2	6			1							
38	Sr	2	2	6	2	6	10	2	6			2							
39	Y	2	2	6	2	6	10	2	6	1		2							
40	Zr	2	2	6	2	6	10	2	6	2		2							
41	Nb	2	2	6	2	6	10	2	6	4*		1							
42	Mo	2	2	6	2	6	10	2	6	5		1							
43	Tc	2	2	6	2	6	10	2	6	5		2							
44	Ru	2	2	6	2	6	10	2	6	7		1							
45	Rh	2	2	6	2	6	10	2	6	8		1							
46	Pd	2	2	6	2	6	10	2	6	10*									
47	Ag	2	2	6	2	6	10	2	6	10		1							
48	Cd	2	2	6	2	6	10	2	6	10		2							
49	In	2	2	6	2	6	10	2	6	10		2	1						
50	Sn	2	2	6	2	6	10	2	6	10		2	2						
51	Sb	2	2	6	2	6	10	2	6	10		2	3						
52	Te	2	2	6	2	6	10	2	6	10		2	4						
53	I	2	2	6	2	6	10	2	6	10		2	5						
54	Xe	2	2	6	2	6	10	2	6	10		2	6						
55	Cs	2	2	6	2	6	10	2	6	10		2	6			1			
56	Ba	2	2	6	2	6	10	2	6	10		2	6			2			

PERIODIC TABLE OF THE ELEMENTS

New notation / Previous IUPAC form / CAS version

KEY TO CHART

Atomic Number ⟶ 50 +2 ⟵ Oxidation States
Symbol ⟶ Sn +4
1989 Atomic Weight ⟶ 118.71
18 18 4 ⟵ Electron Configuration

1 Group IA	2 IIA	3 IIIA IIIB	4 IVA IVB	5 VA VB	6 VIA VIB	7 VIIA VIIB	8 VIIIA VIII	9 VIIIA VIII	10 VIIIA VIII	11 IB	12 IIB	13 IIIB IIIA	14 IVB IVA	15 VB VA	16 VIB VIA	17 VIIB VIIA	18 VIIIA	Shell
1 H +1 −1 1.00794 1																	2 He 0 4.0020602 2	K
3 Li +1 6.941 2-1	4 Be +2 9.012182 2-2											5 B +3 10.811 2-3	6 C +2 +4 −4 12.011 2-4	7 N +1 +2 +3 +4 +5 −1 −2 −3 14.00674 2-5	8 O −2 15.9994 2-6	9 F −1 18.9984032 2-7	10 Ne 0 20.1797 2-8	K-L
11 Na +1 22.989768 2-8-1	12 Mg +2 24.3050 2-8-2											13 Al +3 26.981539 2-8-3	14 Si +2 +4 −4 28.0855 2-8-4	15 P +3 +5 −3 30.97362 2-8-5	16 S +4 +6 −2 32.066 2-8-6	17 Cl +1 +5 +7 −1 35.4527 2-8-7	18 Ar 0 39.948 2-8-8	K-L-M
19 K +1 39.0983 -8-8-1	20 Ca +2 40.078 -8-8-2	21 Sc +3 44.955910 -8-9-2	22 Ti +2 +3 +4 47.88 -8-10-2	23 V +2 +3 +4 +5 50.9415 -8-11-2	24 Cr +2 +3 +6 51.9961 -8-13-1	25 Mn +2 +3 +4 +7 54.93085 -8-13-2	26 Fe +2 +3 55.847 -8-14-2	27 Co +2 +3 58.93320 -8-15-2	28 Ni +2 +3 58.6934 -8-16-2	29 Cu +1 +2 63.546 -8-18-1	30 Zn +2 65.39 -8-18-2	31 Ga +3 69.723 -8-18-3	32 Ge +2 +4 72.61 -8-18-4	33 As +3 +5 −3 74.92159 -8-18-5	34 Se +4 +6 −2 78.96 -8-18-6	35 Br +1 +5 −1 79.904 -8-18-7	36 Kr 0 83.80 -8-18-8	-L-M-N
37 Rb +1 85.4678 -18-8-1	38 Sr +2 87.62 -18-8-2	39 Y +3 88.90585 -18-9-2	40 Zr +4 91.224 -18-10-2	41 Nb +3 +5 92.90638 -18-12-1	42 Mo +6 95.94 -18-13-1	43 Tc +4 +6 +7 (98) -18-13-2	44 Ru +3 101.07 -18-15-1	45 Rh +3 102.90550 -18-16-1	46 Pd +2 +4 106.42 -18-18-0	47 Ag +1 107.8682 -18-18-1	48 Cd +2 112.411 -18-18-2	49 In +3 114.82 -18-18-3	50 Sn +2 +4 118.710 -18-18-4	51 Sb +3 +5 −3 121.757 -18-18-5	52 Te +4 +6 −2 127.60 -18-18-6	53 I +1 +5 +7 −1 126.90447 -18-18-7	54 Xe 0 131.29 -18-18-8	-M-N-O
55 Cs +1 132.90543 -18-8-1	56 Ba +2 137.327 -18-8-2	57* La +3 138.9055 -18-9-2	72 Hf +4 178.49 -32-10-2	73 Ta +5 180.9479 -32-11-2	74 W +6 183.85 -32-12-2	75 Re +4 +6 +7 186.207 -32-13-2	76 Os +3 +4 190.2 -32-14-2	77 Ir +3 +4 192.22 -32-15-2	78 Pt +2 +4 195.08 -32-16-2	79 Au +1 +3 196.96654 -32-18-1	80 Hg +1 +2 200.59 -32-18-2	81 Tl +1 +3 204.3833 -32-18-3	82 Pb +2 +4 207.2 -32-18-4	83 Bi +3 +5 208.98037 -32-18-5	84 Po +2 +4 (209) -32-18-6	85 At (210) -32-18-7	86 Rn 0 (222) -32-18-8	-N-O-P
87 Fr +1 (223) -18-8-1	88 Ra +2 226.025 -18-8-2	89** Ac +3 227.028 -18-9-2	104 Unq +4 (261) -32-10-2	105 Unp (262) -32-11-2	106 Unh (263) -32-12-2	107 Uns (262) -32-13-2												O P Q

*Lanthanides	58 Ce +3 +4 140.115 -20-8-2	59 Pr +3 140.90765 -21-8-2	60 Nd +3 144.24 -22-8-2	61 Pm +3 (145) -23-8-2	62 Sm +2 +3 150.36 -24-8-2	63 Eu +2 +3 151.965 -25-8-2	64 Gd +3 157.25 -25-9-2	65 Tb +3 158.92534 -27-8-2	66 Dy +3 162.50 -28-8-2	67 Ho +3 164.93032 -29-8-2	68 Er +3 167.26 -30-8-2	69 Tm +3 168.93421 -31-8-2	70 Yb +2 +3 173.04 -32-8-2	71 Lu +3 174.967 -32-9-2	N O P
**Actinides	90 Th +4 232.0381 -18-10-2	91 Pa +5 +4 231.03588 -20-9-2	92 U +3 +4 +5 +6 238.0289 -21-9-2	93 Np +3 +4 +5 +6 237.048 -22-9-2	94 Pu +3 +4 +5 +6 (244) -24-8-2	95 Am +3 +4 +5 +6 (243) -25-8-2	96 Cm +3 (247) -25-9-2	97 Bk +3 +4 (247) -27-8-2	98 Cf +3 (251) -28-8-2	99 Es +3 (252) -29-8-2	100 Fm +3 (257) -30-8-2	101 Md +2 +3 (258) -31-8-2	102 No +2 +3 (259) -32-8-2	103 Lr +3 (260) -32-9-2	O P Q

The new IUPAC format numbers the groups from 1 to 18. The previous IUPAC numbering system and the system used by Chemical Abstracts Service (CAS) are also shown. For radioactive elements that do not occur in nature, the mass number of the most stable isotope is given in parentheses.

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